TRANSPORT and ROAD
RESEARCH LABORATORY

Department of the Environment
Department of Transport

SUPPLEMENTARY REPORT 775

AUTOMATIC INCIDENT DETECTION – EXPERIENCE WITH TRRL ALGORITHM HIOCC

by

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Crowthorne, Berkshire
1983
ISSN 0305–1315

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ABSTRACT

An Automatic Incident Detection (AID) system, using computer based algorithms to identify the traffic disturbances following an incident, is under test on a site on the M1 motorway in Bedfordshire. It incorporates the TRRL algorithm HIOCC.

The HIOCC algorithm looks for several consecutive seconds of high detector occupancy, such as would be caused by stationary or slow-moving vehicles, to detect incidents in high traffic flows.

A time lapse television surveillance system has been used to check the causes of alarm messages and to determine whether any incidents have been missed.

Eighteen months experience with HIOCC has shown it to be an efficient incident detection algorithm on the M1 test site detecting hazards caused by slow-moving vehicles, roadworks and accidents, with very few false alarms.

1. INTRODUCTION

A previous report[1] described the automatic incident detection algorithms developed at TRRL for use on motorways. It also referred to an experimental installation on the M1 motorway in Bedfordshire which was designed to assist in the further development and testing of algorithms.

This report describes the installation on the M1 motorway and gives details of the results achieved over 18 months of operation with particular reference to the HIOCC algorithm.

2. INCIDENT DETECTION

An incident is defined as an unusual occurrence, such as an accident, broken down vehicle or shed load, which reduces the capacity of the road on which it occurs. Incidents need to be detected as quickly as possible so that emergency services can provide assistance that might be required by people involved in the incident and approaching drivers can be warned quickly to prevent further accidents.

Information about incidents can be obtained in a number of ways including roadside telephones, police patrols, closed circuit television and vehicle detectors. An automatic system using vehicle detectors, such as the one discussed in this report, is designed to detect the perturbations in the traffic caused by an incident as quickly as possible without causing false alarms.

3. M1 MOTORWAY TEST SITE

The incident detection test site starts about 150 metres north of Junction 11 on the northbound carriageway of the M1 motorway and extends northwards along that carriageway for 3.3 km. There are seven traffic monitoring stations, each having a pair of closely spaced two metre square vehicle detectors of the inductive loop type in each traffic lane. Vehicle detectors were installed in pairs to allow the measurement of individual spot speeds if required although only one detector of each pair is needed in the present detection system. The spacing between monitoring stations was dictated to some extent by the location of existing stations which were to be included in the test site. For an individual detector algorithm such as HIOCC the more closely spaced the detectors are the more efficient the algorithm will be. However, some compromise has to be made between efficiency and practicality and bearing in mind the requirements of other types of algorithm to be tested, the distance between monitoring stations was set at 550 metres. The layout of the test site is shown in Figure 1, each monitoring station being connected to the control centre. The output pulse, produced when each of the 21 vehicle detectors operates, is transmitted to the control centre over a cable link by means of an audio frequency data transmission system with frequency shift keying. In the unattended control centre a Texas Instruments 960A minicomputer scans the 21 detector outputs every one-tenth second. The information obtained is stored on magnetic data cartridges for subsequent off-line analysis and is also used immediately on-line as data for the various algorithms under examination. The HIOCC algorithm operates by detecting stationary or slow-moving vehicles over each vehicle detector and an alarm is operated at a pre-set level of detector occupancy. The alarm is cleared when detector occupancy falls to a selected level. Any alarm and subsequent clearance messages arising from use of the algorithms are printed out in the control centre and collected, together with the data on cartridges, every three days.

4. TV SURVEILLANCE

A continuous visual record of the traffic behaviour through the test site is required so that the reasons for any incident messages can be investigated. This record is obtained using a television camera linked to a time lapse video recorder. The chosen recording rate of one frame approximately every 1.2 seconds gives 72 hours of recording on each 610m reel of video tape. The camera and recorder are mounted in a roadside hut at Station B with the camera looking north along the motorway. The field of view extends from half way between Stations B and C to just beyond Station F where the road continues over the brow of a hill. In good visibility the monochrome recording is clear enough to determine makes of vehicles but not registration numbers. During the hours of darkness traffic movement is monitored by watching the progress of rear lights through the test site.

Every video tape is examined for the occurrence of incidents whether or not any incident messages have been generated. The video tapes are played back at 50 frames/second, approximately 60 times the recording rate, when it is possible for an experienced observer to detect disturbances in the traffic flow which may have been caused by incidents. Any disturbances found can be examined in detail by slowing down the playback speed.

5. INCIDENT DATA

The messages produced by the HIOCC algorithm at the onset of an incident give the time, location and lane. Although it is not possible for the algorithm to decide what the incident is examination of the television recordings has shown that, in general, alarms are caused by slow-moving vehicles and roadworks as well as accidents. During the 18 month period covered by this report there were 130 alarm message sets. Table 1 gives the number of message sets associated with each cause. The messages labelled in Table 1 as 'not visible', occurred at locations out of sight of the TV surveillance system or in conditions of poor visibility thus preventing a valid reason being found.

TABLE 1

Cause of message	No. of message sets	% of total
Slow-moving vehicle	42	32.3
Roadworks	41	31.5
Accidents	10	7.7
Not visible	30	23.1
Hardware faults	3	2.3
No reason found	4	3.1
Total	130	100.0

Four incidents were reported by the police during the study period which were not detected by the automatic system. Two occurred whilst the computer was out of action; the third, in which a car left the carriageway and went down an embankment behind the hard shoulder, was out of view on the video recording but was verified at the site. The fourth reported incident, involving a heavy goods vehicle stopped in the nearside lane at night, could not be found at the time and location given despite a careful search of the video recording and it is possible the location was wrongly reported.

6. SLOW-MOVING VEHICLES

An examination of more than 800 accident report forms from the Bedfordshire section of the M1 motorway showed that one per cent of all motorway accidents can be directly attributed to the presence of a slow-moving vehicle. It is reasonable, therefore, to consider that vehicles travelling slowly enough to trigger the alarm warning can be considered a hazard.

A slow-moving vehicle typically gives a series of alarm messages, one for each detector station, as it passes through the test site. Such a 'set' of messages is considered as one alarm for the purpose of this report. With the HIOCC parameters now in use on the test site (100 per cent occupancy for 3 seconds to set off an alarm) a 30 metre long abnormal load travelling at less than 40 km/h (25 mile/h) triggers an alarm message, whereas a typical 14 metre long articulated lorry has to be travelling at less than 20 km/h (12 mile/h) and a 4.5 metre long car at less than 8 km/h (5 mile/h). All 42 of the slow-moving vehicles which caused alarm messages were in the nearside lane.

An analysis of 10 of the 'sets' of alarm messages caused by slow-moving vehicles gave an average time between messages at adjacent detector stations of about 50 seconds, equivalent to a speed of 40 km/h (25 mile/h) for detectors spaced at 550 metres. The duration of any alarm state caused by a slow-moving vehicle is affected by the flow of traffic passing over the detector behind the slow vehicle. An alarm state could, for instance, be prolonged if the slow vehicle has a Police escort following at some distance to encourage approaching drivers to leave the occupied lane. In 9 of the 10 cases considered the alarm state at each detector station lasted for approximately 2½ minutes, the remaining one lasted for nearly 4 minutes. All vehicles except one passed through the test site between 1000 hrs and 1500 hrs, the exception being at 0740 hrs.

A graphical presentation of a typical set of messages generated by a long load with a Police escort is shown in Figure 2.

7. ROADWORKS

HIOCC alarm messages associated with roadworks are usually caused by a maintenance vehicle being driven slowly through the site in order to set down cones to segregate the work area from the traffic. Such alarm messages, at each detector station in turn as the vehicle moves northwards through the test site, look like a slow-moving vehicle as before but can start at any detector station and are, of course, in the lane being coned off. However, because traffic is not able to use the coned-off lane no clearance message is printed until the lane is re-opened and traffic flows normally. The same applies to messages caused by vehicles manoeuvring in the work area. On rare occasions the vehicle which is picking up the cones, when the maintenance work is finished, is travelling slowly enough to give incident messages. The messages in this case move south through the site, much more rapidly than the queue builds back from an accident and, again, are confined to the lane which was closed. Clearance messages follow quickly as traffic starts to use the lane again.

8. ACCIDENTS

Before any accident can be detected by the HIOCC algorithm its effect on the traffic must result in vehicles either being stationary, or travelling so slowly over a vehicle detector that the occupancy exceeds a pre-set threshold. Whether an accident will cause this to happen will depend on its location relative to the nearest upstream detector, the reduction in carriageway capacity and the traffic flow.

There were 14 accidents on, or affecting, the M1 test site during the period covered by this report, 10 of which caused perturbations which were detected by the HIOCC algorithm. Six of the accidents occurred at various distances north of the test site, three within 400 metres, and caused queues to form which were detected as soon as they reached back to Station G. Four accidents occurred at various positions along the test site and were detected, but as already discussed in Section 5, two more were not detected because the computer was not operative and a further two reported accidents were missed entirely.

Figure 3 is a schematic plot of the accidents that affected the test site and shows that accidents occurred in all lanes. One accident north of Station G, involving five vehicles, blocked all three traffic lanes. Another, which resulted in a large spillage of oil across the carriageway also seriously reduced the carriageway capacity. The accident in the centre lane between stations C and D affected the nearside lane as well. It is not known which lanes were affected by the accidents adjacent to the service area and junction 12 but all the remaining accidents were confined to the lane in which they occurred. Traffic flow at the time of the accidents varied between 430 veh/h and 2300 veh/h.

The time delay between an incident occurring and an alarm being given – the algorithm response time – is an important measure of the algorithms efficiency. The use of continuous television monitoring of the test site should enable some measure of the response time to be made for HIOCC. Unfortunately, only two incidents detected by HIOCC have occurred within sight of the television camera. Both of these incidents produced alarm messages within 30 seconds of the initial happening. The response time is of course affected by the distance between the original incident and the nearest upstream detector.

Figure 4 gives the pattern of alarm messages on the site caused by an incident north of Station G.

9. OTHER INCIDENTS

There were two occasions when shed loads may have caused problems to approaching traffic in the test site but neither caused the traffic to slow down enough to cause HIOCC alarms.

10. FALSE ALARMS

Clearly, the number of false alarm messages produced by any incident detection system should be kept low to prevent the system dropping into disrepute. This is especially important on a site not equipped with closed circuit television where alarm messages can only be verified by dispatching a police vehicle to the scene.

The HIOCC algorithm, provided all the associated hardware is working correctly, can only give an alarm message when a detector has been occupied as defined in the algorithm parameters. However, during the course of this trial seven alarms have occurred for which there was no apparent traffic reason; three being caused by faults in the data transmission system. Of the remaining four messages three were from the nearside lane of Station F, only just in range of the television camera, and were probably caused by heavy goods vehicles slowing just enough to trigger the alarm at the top of the incline on the test site. No reason could be found for the remaining alarm.

11. CONCLUSIONS

The HIOCC algorithm has proved to be an efficient incident detection algorithm for the M1 motorway test site. Over a period of eighteen months slow-moving vehicles, roadworks and accidents caused 93 alarm messages. Only seven messages were classified as false alarms, three of these being caused by hardware faults. Two incidents involving shed loads were not detected by HIOCC but neither caused any congestion. Two accidents occurring on the test site whilst the incident detection equipment was running were not detected but neither affected traffic on the carriageway. All other known incidents that occurred within the test site, or which caused congestion in the test site, were detected.

12. ACKNOWLEDGEMENTS

The work described in this report was carried out in the Highway Traffic Division (Division Head: Mr K Russam) of the Traffic Engineering Department of TRRL.

13. REFERENCES

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2. COLLINS, J.F. Incident detection experiments on the Boulevard Périphérique in Paris. *Department of the Environment Department of Transport, TRRL Report* SR 362. Crowthorne, 1977 (Transport and Road Research Laboratory).

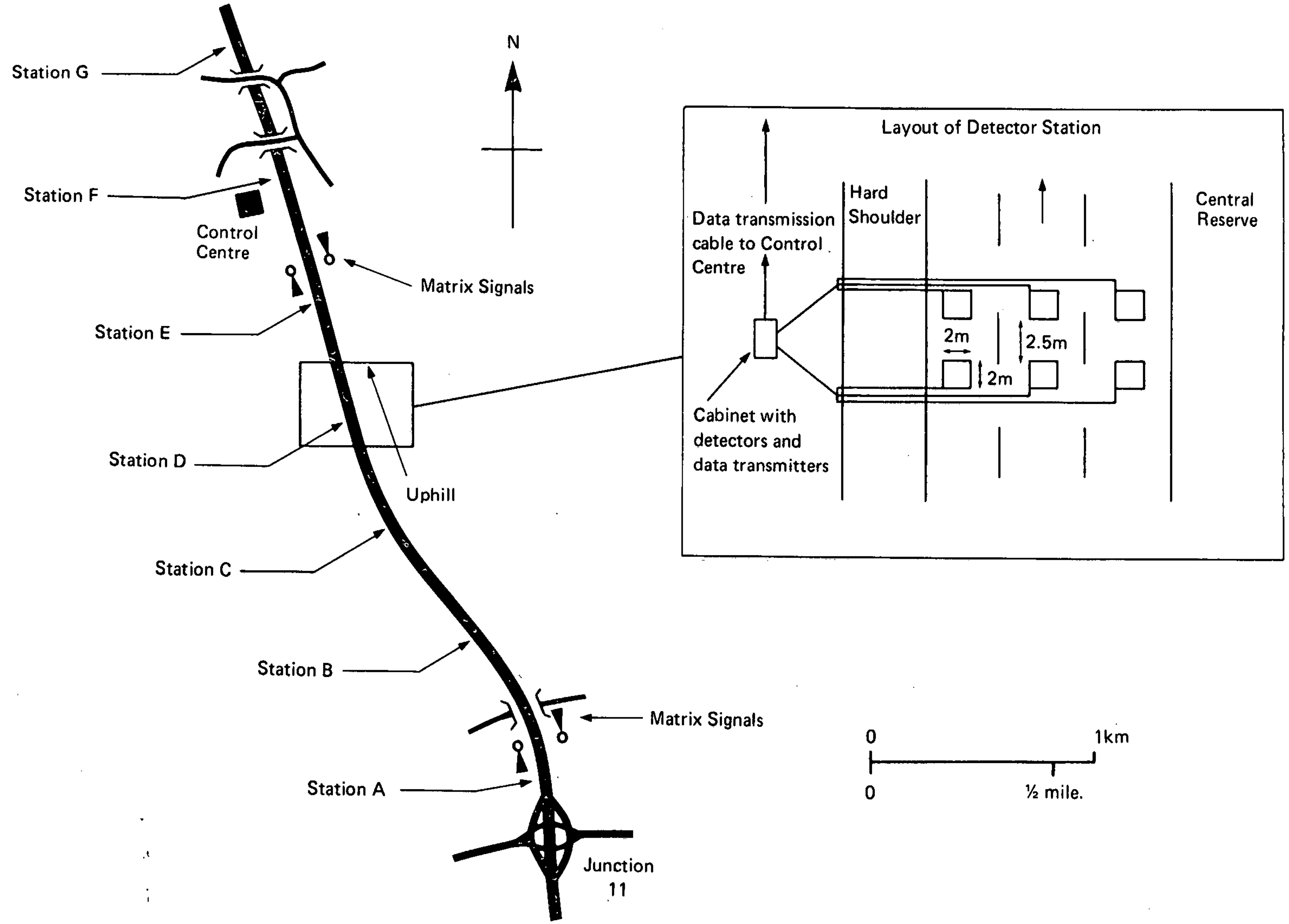

Fig. 1 MI experimental site for automatic incident detection

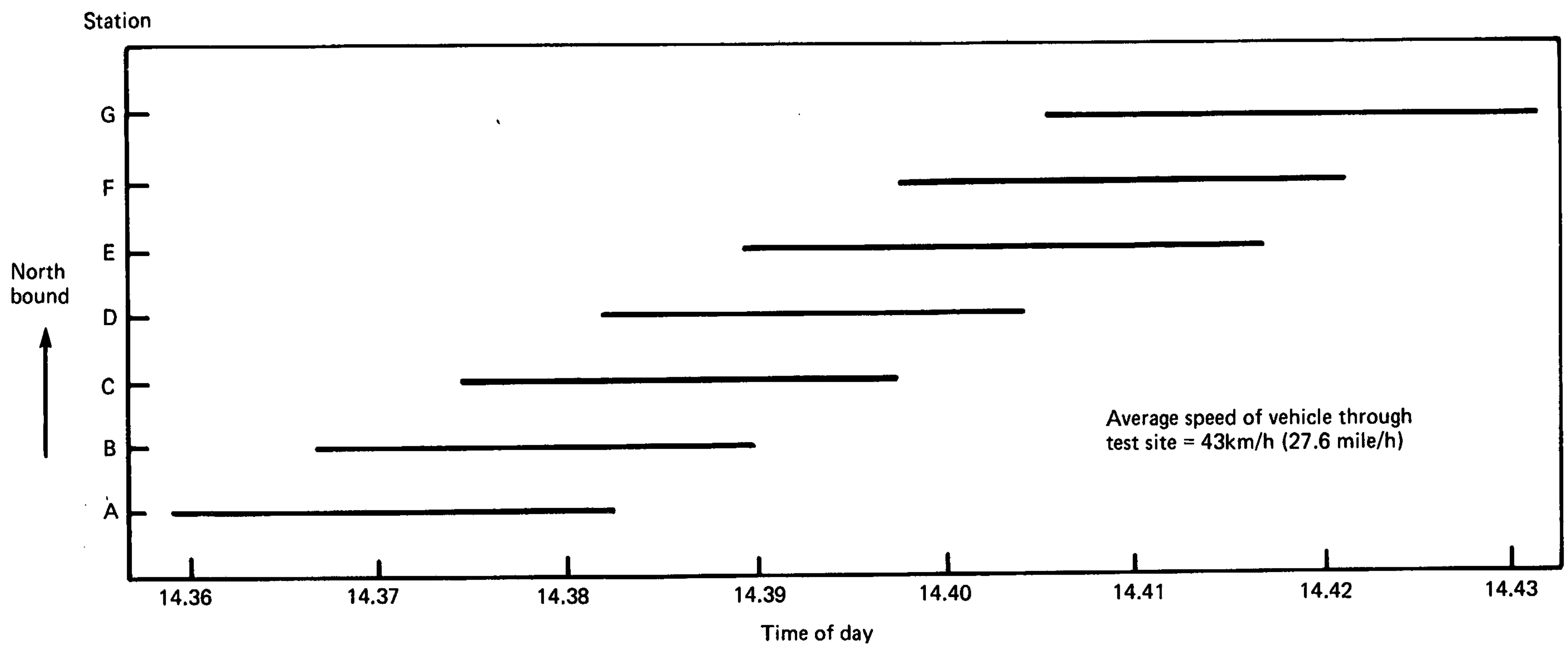

Fig. 2 Times of H IOCC alarm messages caused by a long vehicle with Police escort

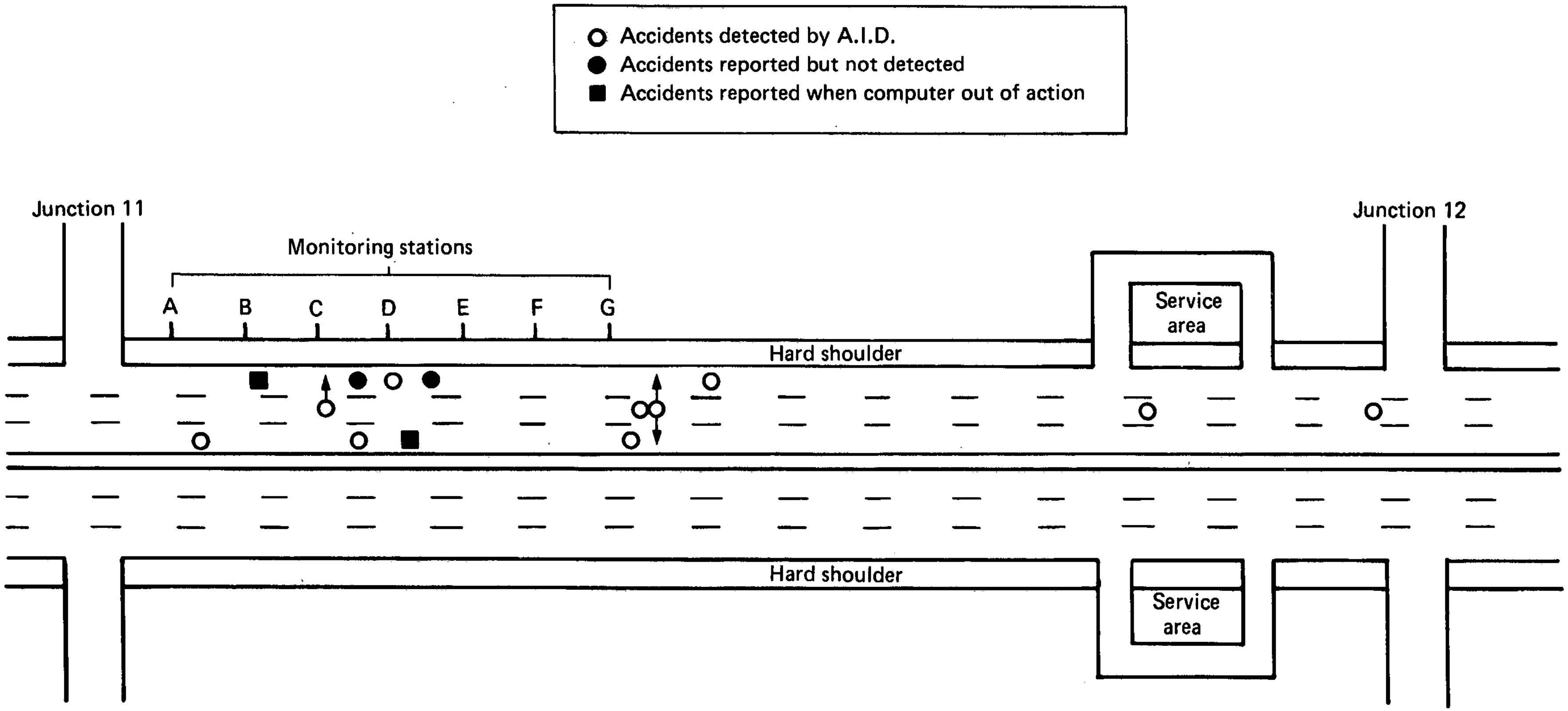

Fig. 3 Accidents affecting test site

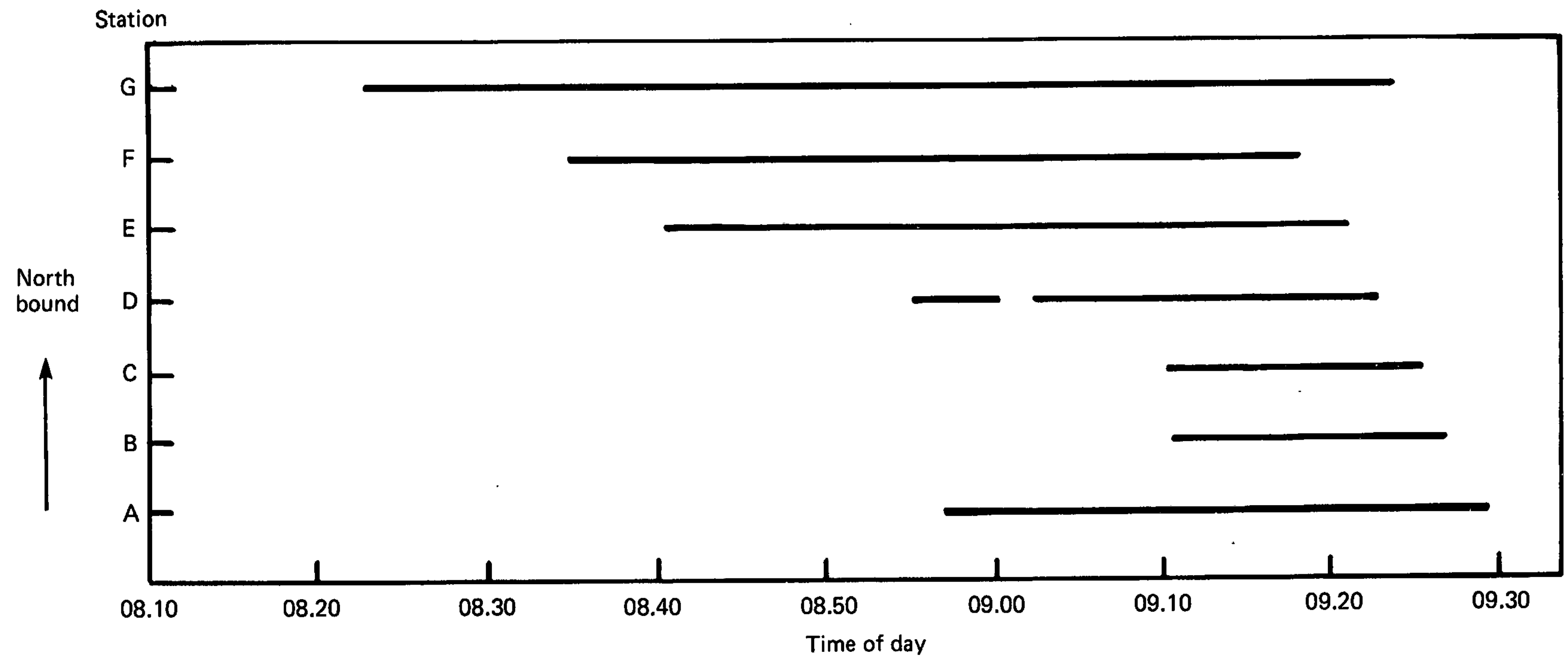

Fig. 4 Times of H10CC alarm messages caused by an accident north of Station G (nearside lane only plotted)

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PRINTED IN ENGLAND

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